The Euler Virtual Math Fonts for use with LaTeX

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Abstract

The Euler math fonts are suitable for math typesetting in conjunction with a variety of popular text fonts which do not provide math character sets of their own. Euler-VM is a set of virtual math fonts based on Euler and CM, accompanied by a macro package for easy use with LaTeX.

Contents

1 The Euler math fonts

'With Donald Knuth's assistance and encouragement, Hermann Zapf, one of the premier font designers of this century, was commissioned to create designs for Fraktur and script, and for a somewhat experimental, upright cursive alphabet

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that would represent a mathematician's handwriting on a blackboard and that could be used in place of italic. The designs that resulted were named Euler, in honor of Leonhard Euler, a prominent mathematician of the eighteenth century. Zapf's designs were rendered in METAFONT code by graduate students at Stanford, working under Knuth's direction. [...] Knuth also noticed that the style of some symbols in the Computer Modern extension font, in particular the integral sign, was too slanted to be attractive with Euler, and consequently he prepared a new (partial) extension font for use with Euler.' [1]

Knuth's book *Concrete Mathematics* was typeset using the Concrete font family for text and the Euler fonts for math. With LaTeX, the particular math font setup of this book can be mimicked by means of the package euler, see [4]. In the meantime it became obvious that the Euler fonts match other text font families equally well.

Unfortunately, the Euler fonts do not comprise all symbols required for mathematical typesetting with LaTeX. As a result, the euler package needs to redefine most of LaTeX's math font setup, so that certain symbols are taken from Euler, whereas others must still come from the CM math fonts.

2 The Euler-VM fonts

Euler Virtual Math (Euler-VM) is a set of *virtual* fonts based primarily on the Euler fonts. The missing symbols are taken from Computer Modern, and the encoding follows CM-Math as closely as possible. This approach has several advantages over immediately using the *real* Euler fonts, as practiced in the euler package: Most noticeably, less TeX resources are consumed, the quality of various math symbols is improved, and there will be far lesser compatibility problems with other packages.

Actually, the reason for creating Euler-VM was the fact that the euler package does not provide a usable `\hbar` or `\hslash`, and that the `\hslash` symbol from the amssymb package cannot be used, either, because it follows CM Roman style. This made the beautiful Euler fonts more or less unusable for physics and related fields. The only way to fix this was to provide a 'faked' Euler-style `\hslash` using the virtual font mechanism. As a side effect, it was possible to make the layout of the virtual fonts compatible with CM Math to a large extent, and – since the style file had to be rewritten anyway – further improvements were introduced.

3 Suitable text font families

Beside the above-mentioned Concrete, the font families Palatino, Aldus and Melior blend well with Euler – which is not surprising, since they were designed by H. Zapf, too. The Euler math fonts have also proven to go sufficiently well with other typefaces such Sabon[1] or Minion, that do not differ too much from Euler as far as the weight (stroke width) and x-height are concerned.

Changing the default text font family is easy, see [3]. For instance, in the present document the command

```
\renewcommand{\rmdefault}{pplx}
```

makes LaTeX use Palatino in place of CM Roman.

[1] the classical one, not Sabon Next – unfortunately

Do *not* use the Euler math fonts in conjunction with the default Computer Modern text fonts – this is ugly!

4 The LaTeX package eulervm

Loading the eulervm package will redefine LaTeX's math font setup, so that the Euler-VM fonts and the default body font are substituted for CM Math and CM Roman. Roughly said:

- ▷ CM Math Italic is replaced with Euler Roman.
- ▷ CM Calligraphic is replaced with Euler Script.
- ▷ Several operator and delimiter symbols are replaced with alternative variants matching the Euler style.
- ▷ In numbers and operator names, CM Roman is replaced with the default text font.

Figure 1 shows the Euler Roman and Script alphabets.

4.1 Special features

4.1.1 The package option small

Loading the package with the option small causes the Euler fonts to be loaded at 95% of their nominal size, thus blending better with certain text font families, for instance Aldus or Minion. The option acts also on the AMS symbols and Euler Fraktur fonts, which can be used by means of the amssymb and eufrak packages; any further math fonts used in your document are, however, unaffected.

4.1.2 Slashed *h*

In contrast to 'normal' LaTeX, a `\hslash` symbol ħ is provided, but there is no `\hbar`.

4.1.3 Bold math alphabet

The package defines a new math alphabet `\mathbold` to typeset math variables, incl. Greek, in a bold style:

Default: $a, b, c, \ldots, z$ `\mathbold`: $\mathbf{a}, \mathbf{b}, \mathbf{c}, \ldots, \mathbf{z}$

Do not mix this up with `\mathbf`: The latter will produce characters from the bold *text* font, whereas `\mathbold` will use the bold series of the Euler math font.

$$
\begin{array}{c}
ABCDEFGHIJKLMNOPQRSTUVWXYZ \\
abcdefghijklmnopqrstuvwxyz \\
\Gamma\Delta\Theta\Lambda\Xi\Pi\Sigma\Upsilon\Phi\Psi\Omega \\
\alpha\beta\gamma\delta\varepsilon\zeta\eta\theta\vartheta\iota\kappa\lambda\mu\nu\xi\pi\varpi\rho\sigma\tau\upsilon\phi\varphi\chi\psi\omega \\
\mathcal{ABCDEFGHIJKLMNOPQRSTUVWXYZ}
\end{array}
$$

Figure 1: The Euler Roman and Script alphabets

4.1.4 Size of the 'large' math symbols

The size of the 'large' math symbols is automatically adjusted with respect to the base font size. You need *not* load the extra package exscale for this purpose.

4.2 Text fonts in math

4.2.1 Math alphabets

Function names as well as math accents are taken from the default text font family. This holds for the math alphabets `\mathrm` and `\mathbf`, too. The eulervm package determines the default font family (i.e., the meaning of the macro `\familydefault`) at load time and will apply it for the above purposes then. In the same way, the math alphabets `\mathsf` and `\mathtt` are mapped to `\sfdefault` and `\ttdefault`. Thus, you should redefine the default text fonts *before* loading the eulervm package!

4.2.2 Numbers and punctuation in math mode

The normal behavior is to take the digits, the comma and the period from the default text font family. Popular text fonts may, however, not be suitable for typesetting math: Maybe the numeral '1' cannot be distinguished clearly enough from the letter 'l', or the style of the numerals does not sufficiently suit the Euler letters, or you are using oldstyle digits. Furthermore, most text fonts are scaled linearly, so that the digits may become too thin when used in super- or subscripts.

The eulervm package provides the option euler-digits, which makes the digits, the comma and the period come from Euler Roman in math mode. Note that the Euler fonts come with separate designs sizes of 10 pt, 7 pt and 5 pt! The option should be used with care, because entering `$1.23$` will yield a different result than `1.23` then, and you will in each case have to decide whether an input fragment is a math or a non-math entity. The samples on page 6 show the Euler digits.

4.2.3 The 'hat' accent for math

By default, the math accent `\hat` is taken from the text font With the option euler-hat-accent, an alternative one from Euler Fraktur will be used. Compare the default accent (in the present document from Palatino) with the alternative variant:

$$\hat{u} \longleftrightarrow \hat{u}$$

4.2.4 Encoding

The default text font encoding (i.e. the meaning of the macro `\encodingdefault`) is determined when eulervm is loaded; this encoding will then be applied to any text fonts used in math mode (see above.) The eulervm package can, however, handle the encodings OT1 (LaTeX's default), T1 and LY1 only. If your preferred text font encoding is a different one, or if you want to override the default setting for one reason or another, you have to specify one of the above as a package option, e.g.:

```
\usepackage[OT1]{eulervm}
```

This makes the eulervm package use the given encoding for the text fonts in math, without affecting text mode. Be sure that the text fonts are actually available with this encoding!

4.3 Using PostScript fonts

The CM as well as the Euler fonts are available in both METAFONT and Type1 (PostScript) format. The collection of Type1 fonts distributed by the AMS (or in conjunction with VTeX, resp.) is, however, lacking a few sizes. In contrast to the euler package, eulervm does *not* make use of these missing fonts; thus, you can create documents which do not require any bitmap fonts.

4.4 Options and command summary

Options of the eulervm package:

- ▷ small Load the Euler fonts at 95% of their nominal size.
- ▷ euler-digits Take numerals, comma and period from Euler Roman in math mode.
- ▷ euler-hat-accent Use the `\hat` accent from Euler Fraktur.
- ▷ OT1 Use OT1 encoding for text fonts in math, regardless of the default text font encoding.
- ▷ T1 ditto, T1
- ▷ LY1 ditto, LY1

New commands:

- ▷ `\mathbold` A bold Euler-style math alphabet.
- ▷ `\hslash` A slashed Euler-style h.

4.5 Known problems and deficiencies

- ▷ Certain symbols in the bold math fonts are far from perfect. E.g., the bold equals sign of the Euler fonts is actually smaller than the regular one!
- ▷ The dot-generating macros such as `\dots`, `\dots` etc. take their dots from different fonts. This results partially from a design flaw in LaTeX, which can be fixed by loading of the package mathdots; yet, the macros `\cdot` and `\cdots` will always produce dots from the Computer Modern Symbols font, which may not perfectly match the other dot symbols used.

5 Credits

Frank Jensen's euler package [4] served as a model for parts of eulervm. The implementation of the OT1, T1 and LY1 options was adopted from Frank Mittelbach's lucidabr package [5]. Special thanks to Henning 'Hraban' Ramm for typographical and Frank Mittelbach for TeXnical advice.

6 Sample Formulas

From the METAFONT book, p. 298

[...] If $n > 2$, the identity

$$t[u_1, \ldots, u_n] = t\bigl[t[u_1, \ldots, u_{n_1}], t[u_2, \ldots, u_n]\bigr]$$

defines $t[u_1, \ldots, u_n]$ recursively, and it can be shown that the alternative definition

$$t[u_1, \ldots, u_n] = t\bigl[t[u_1, u_2], \ldots, t[u_{n-1}, u_n]\bigr]$$

gives the same result. Indeed, we have

$$t[u_1, \ldots, u_n] = \sum_{k=1}^{n} \binom{n-1}{k-1} (1-t)^{n-k} t^{k-1} u_k \,,$$

a Bernstein polynomial of order $n - 1$.

From the METAFONT book, p. 59

$$\frac{x_1 + 20}{x_2 - 20} + \sqrt{a^2 - \frac{2}{3}\sqrt{b}}$$

From the TeX book, exercise 19.13

$$\int_{-\infty}^{+\infty} e^{-x^2}\, dx = \sqrt{\pi}$$

References

[1] American Mathematical Society:
User's Guide to AMSFonts Version 2.2.
Jan. 1995.
CTAN: `fonts/amsfonts/doc/amsfndoc.ps`

[2] Ronald L. Graham, Donald E. Knuth, and Oren Patashnik:
Concrete Mathematics.
Addison-Wesley, 1989.

[3] LaTeX3 Project Team (Ed.):
LaTeX2e font selection. (Part of the LaTeX online documentation.)

[4] Frank Jensen:
The euler package, v2.5.
Mar. 1995.
CTAN: `macros/latex/contrib/euler/`

[5] Frank Mittelbach:
The lucidabr package, v4.10.
Jan. 1998.
CTAN: `macros/latex/contrib/psnfssx/lucidabr/`